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A heart stimulating d vice, a system including such a d vice and use of the system

BACKGROUND OF THE INVENTION

1. Field of the invention

The present invention relates to an implantable heart monitoring and stimulating device with which it is possible to stimulate both the ventricles of a heart, i.e. a bi-ventricular pacer. The invention also relates to a system including such a device and to the use of the system.

2. Description of the prior art

Several different implantable devices for monitoring and stimulating a heart are known. The devices are normally able to sense the electrical activity of the heart and to deliver stimulation pulses to the heart. Some implantable devices are able to sense, and deliver stimulation pulses to, both the left and right ventricle of the heart.

Devices that are able to deliver stimulation pulses to both the left and right ventricle are also called bi-ventricular pacers. Such devices can be used to treat patients who suffer from different severe cardiac problems, e.g. patients suffering from congestive heart failure (CHF). CHF is defined generally as the inability of the heart to deliver a sufficient amount of blood to the body. CHF can have different causes. It can for example be caused by a left bundle branch block (LBBB) or a right bundle branch block (RBBB). By using bi-ventricular pacing, the contraction of the ventricles can be controlled in order to improve the ability of the heart to pump blood. The stimulation pulses to the two ventricles can be delivered simultaneously but it is also known that the stimulation pulses to the

two ventricles are delivered with a short time delay between them in order to optimise the pumping performance of the heart.

US-A-5 720 768 describes different possible electrode positions in order to stimulate or sense the different chambers of the heart.

US-A-6 070 100 describes that electrodes may be positioned to sense and stimulate both the left and the right atrium as well as the left and the right ventricles.

In connection with implantable heart stimulating devices, it is thus known to sense different signals with the help of the implanted electrodes and to control the heart stimulating device in response to sensed signals. It is for example known to inhibit the delivery of a stimulating pulse if a natural, intrinsic, heart activity is detected. One difficulty in this context is to identify the signals that the device senses. Signals may originate from different intrinsic events in different parts of the heart. Signals may also originate from the heart stimulating device itself, i.e. from pulses delivered by different implanted electrodes. Signals may even have external causes, for example an external electromagnetic alternating field to which the person with the implanted device is exposed.

One kind of detected signal is a so-called far field signal. This is a signal that is detected by an implanted electrode, but which originates from some other part of the heart that than that which it is intended to sense with the electrode in question. This phenomenon is known in connection with pacers arranged to sense or stimulate both the right atrium and the right ventricle. It is for example known that an electrode positioned in the right atrium may sense an R wave, i.e. a QRS complex, when this electrode actually should sense a P wave. The sensed R wave is thus in this case a far field signal. Different ways to avoid this problem have been suggested in connection with pacers arranged to sense or pace the right atrium and the right ventricle.

In connection with bi-ventricular pacers, or four chamber pacers, different kinds of problems concerning far field detection may occur than those known in connection with pacers arranged to sense or pace only the right atrium and the right ventricle.

SUMMARY OF THE INVENTION

The inventors of the present invention have realised a problem that may occur in an implantable heart stimulating device which has means arranged for sensing signals related to both the left ventricle and the right ventricle of a heart. The problem is that a detected signal could in fact originate from the other ventricle than that which it is intended to detect. In other words, the detected signal could be a far field signal from the other ventricle. An object of the present invention is therefore to provide an implantable heart stimulating device with which it is possible to distinguish a far field signal which may originate from the other ventricle from a signal from the ventricle which it is intended to detect. The problem with a far field signal occurs when signals are detected essentially simultaneously by sensing means designed to detect signals in the two ventricles.

The above object is achieved by an implantable heart stimulating device comprising:

a control circuit comprising a memory, first sensing means, adapted to be connected to a first sensing member suited to be positioned so as to transfer signals to said first sensing means for sensing cardiac events related to a first ventricle of the heart, and second sensing means, adapted to be connected to a second sensing member suited to be positioned so as to transfer signals to said second sensing means for sensing cardiac events related to a second ventricle of the heart,

said control circuit also comprising first stimulation means adapted to be connected to a first stimulation member for delivering stimulation signals to the first ventricle of the heart, and second stimulation means adapted to be connected to a second stimulation

member for delivering stimulation signals to the second ventricle of the heart,

said control circuit also being arranged to be able to detect or determine a time cycle corresponding to a normal heart cycle, the control circuit also being arranged to perform the following algorithm:

a) determine whether, during a time cycle in which no stimulation signal is delivered by said second stimulation means, a signal S2a, sensed by said second sensing means, occurs essentially simultaneously with a signal S1a sensed by said first sensing means,

b) determine whether a further signal S2b is sensed by said second sensing means within a predetermined time interval T2 which follows after said signal S2a but within the same time cycle as said signal S2a, wherein said predetermined time interval T2 starts 20-200 ms after said signal S2a,

c) if both a) and b) are the case, store in said memory an indication of the fact that said signal S2a, which constitutes a suspected far field signal, has been detected.

It can be noted that the mentioned time cycle can be determined by simply defining a normal time for a heart cycle, for example about 1s, or by detecting events which signify a heart cycle. It should also be remarked that the concept "essentially simultaneously" means that the signals occur exactly simultaneously or that there is a very small time interval between them, for example less than 25 ms. If there is such a short time interval between the signals S1a and S2a, then it is difficult to determine which sensing member is closest to the electrical activity. This means that there is a risk that, in this case, the signal S2a is a far field signal.

In case the signal S2a is a far field signal, then there is a risk, according to this example, that the control circuit "interprets" this signal S2a, as if it is in fact an intrinsic signal originating from the second ventricle. Depending on the operation mode of the heart stimulating device, such a detected signal could influence the operation

of the device. For example, such a signal could mean that a stimulation pulse to the second ventricle is inhibited.

According to the invention, the mentioned time interval T2 is monitored in order to detect whether a signal occurs within this time interval. A signal will occur in the time interval T2 if the signal S2a was in fact not an intrinsic signal from the second ventricle but a far field signal from the first ventricle, i. e. in case no intrinsic depolarisation has occurred in the second ventricle. However, the depolarisation in the first ventricle will via the myocardium reach the second ventricle with a delay. It is such a delayed depolarisation in the second ventricle that is sensed within the time interval T2. If the signal S2a was in fact an intrinsic depolarisation in the second ventricle, then the second ventricle would be biologically refractory during the time interval T2 and no depolarisation could therefore occur. A signal within the time interval T2 thus means that the signal S2a was in fact not an intrinsic depolarisation in the second ventricle but most likely a far field signal from the first ventricle.

According to one preferred embodiment of the invention, said predetermined time interval T2 is 40-250ms long, preferably 50-150 ms or 50-100 ms. The predetermined time interval T2 can according to one embodiment start 50-150 ms after said signal S2a. The start and the length of the time interval T2 can be selected according to the particular case. Preferably, the time interval T2 occurs within the ventricular refractory period that is often set to be about 230 ms. A suitable start and length of the time interval T2 thus depends on the expected time delay for the signal S2b to reach the second ventricle. In a particular case, this depends inter alia on the location of the electrode members when the device has been implanted in a living being.

The control circuit is preferably arranged to perform said algorithm during a plurality of time cycles and to adjust the setting of at least one control variable of the device if said signal S2a, which constitutes a suspected far field signal, has been detected during at least a predetermined number of time cycles. The adjustment can be an

increase of the sensing threshold. The predetermined number of time cycles could for example be 2, 5 or 10. The device could also be arranged such that said predetermined number of time cycles have to occur within a certain time span in order for the device to adjust the setting of the control variable. For example, there could be a requirement that the predetermined number of time cycles occur within one minute or one hour. By for example increasing the sensing threshold, the risk for far field sensing is reduced.

According to another preferred embodiment, said control circuit is arranged to also:

determine whether, during a time cycle in which no stimulation signal is delivered by said first stimulation means and no stimulation signal is delivered by said second stimulation means, in addition to said signal S2b also a signal S1b is detected, wherein the signal S1b fulfils the following criteria:

the signal S1b is sensed by said first sensing means within a predetermined time interval T1 which follows after said signal S1a but within the same time cycle as said signal S1a, wherein this predetermined time interval T1 starts 20-200 ms after said signal S1a,

wherein the control circuit is arranged to store in said memory an indication that both said signal S1b and said signal S2b have been detected during a time cycle. According to this embodiment, detection has thus been done both within the time interval T1 and T2. If such signals are detected, this is an indication that the signals S1a and S2a are caused by an external interference. The device can thus be arranged to take into account that an external interference probably is the case.

It should be observed that the terms S1a, S2a, S1b, S2b, T1 and T2 are used in this document only in order to distinguish the different signals and time intervals from each other.

Preferably, said predetermined time interval T1 at least substantially coincides with said predetermined time interval T2.

The control circuit can be arranged to set at least one timer period in response to detected signals S1a and/or S2a, and wherein, when both said signal S1b and said signal S2b have been detected during a time cycle, the control circuit is arranged to modify said set timer period. The timer period that is set in response to detected signals S1a and/or S2a can involve the resetting of a timer period, wherein said modification can be that the resetting of the timer period is annulled.

According to another aspect of the invention, the invention provides an implantable heart stimulating system comprising a device according to any of the above embodiments and a first and a second lead connected to the device, wherein said first sensing member is arranged on said first lead and said second sensing member is arranged on said second lead. Preferably said first stimulation member is the same member as said first sensing member and said second stimulation member is the same member as said second sensing member. With such a system, the advantages described above are achieved.

According to another aspect, the invention concerns a use of such a system. According to this use, the system is implanted in a human or animal being and said first sensing member is positioned in or at a first of the ventricles of the heart of said human or animal being and said second sensing member is positioned in or at the second ventricle of said heart.

According to a preferred manner of using the system, the control circuit is preferably arranged to sense said signals S1a and S2a during a portion of the heart cycle where possible R-waves are expected to be sensed in the ventricles, and wherein said algorithm is used to detect whether the signal S2a is in fact not a sensed R-wave from the second ventricle but a suspected far field signal from the first ventricle. Preferably, information about detection of one or more such suspected far field signals are stored in said memory such that this information is accessible to a physician at a medical check-up.

The system is with advantage used on a human or animal being suffering from congestive heart failure, for example caused by a left or right bundle branch block. By using the system in the manners described above, appropriate measures may be taken in response to the detection of suspected far field signals.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig 1	shows schematically a heart stimulating system with a heart stimulating device connected to leads with sensing and stimulation members positioned in a heart.
Fig 2	shows schematically a control circuit which may form part of the device.
Fig 3	shows schematically on a time scale signals sensed by first and second sensing means.
Fig 4	shows a simplified flow chart of the operation of the device.

DESCRIPTION OF PREFERRED EMBODIMENTS

Fig 1 shows schematically an implantable heart stimulating device 10 according to the invention. The device 10 comprises a housing 12. The device 10 includes a control circuit 14 (that will be described more in connection with Fig 2). The device 10 has a connector portion 13. The device 10 is in the illustrated embodiment connected to different leads 30, 40, 50, 60.

Fig 1 also schematically shows a heart including a right atrium RA, a left atrium LA, a right ventricle RV and a left ventricle LV.

A first lead 30 includes electrode member 31, 32 positioned in the right ventricle RV of the heart. The electrode 31 may be called tip electrode and the electrode 32 can be called a ring electrode. In this example, the first lead 30 thus includes bipolar electrodes.

However, it is within the scope of the invention that instead the device 10 is connected to unipolar electrodes as is known to a person skilled in the art. The electrodes 31, 32 constitute a first sensing member 31, 32 suited to sense cardiac events related to a first ventricle 1V (in this case the right ventricle RV). The electrodes 31, 32 also function as a first stimulation member 31, 32 for delivering stimulation signals to the first ventricle 1V.

A second lead 40 is connected to the device 10. The second lead 40 includes in the shown embodiment bipolar electrodes 41, 42. These electrodes constitute a second sensing member 41, 42 positioned for sensing events related to the second ventricle 2V (in this case the left ventricle LV). The electrodes 41, 42 also constitute a second stimulation member 41, 42 for delivering stimulation signals to the second ventricle 2V. The second lead 40 may for example be introduced via the right atrium and the coronary sinus such that the member 41, 42 is positioned in for example the middle or great cardiac vein of the heart. How to introduce the second lead 40 in this manner is known to a person skilled in the art.

According to the shown embodiment, the device is also connected to a third lead 60 with electrode members 61, 62. These electrode members are positioned in the right atrium RA in order to be able to sense and stimulate this atrium. The device 10 is in this case also connected to a fourth lead 50 with electrode members 51, 52. These electrode members may be positioned in the coronary sinus in order to sense and stimulate the left atrium LA of the heart.

The device 10 together with at least two leads 30, 40 thus constitute an implantable heart stimulating system according to the invention.

Fig 2 shows schematically the control circuit 14 in some more detail. The control circuit 14 includes at least one memory 15. Furthermore, the control circuit 14 comprises first sensing means 16 and first stimulation means 18. These means are adapted to be connected to the first lead 30 in order to sense and stimulate the

first ventricle 1V. The means 16, 18 are also connected to a control portion 20 of the control circuit 14.

The control circuit 14 also includes second sensing means 17 and second stimulation means 19. These means 17, 19 are adapted to be connected to the second lead 40 in order to sense and stimulate the second ventricle 2V. The means 17, 19 are also connected to the control portion 20 of the control circuit 14.

The control circuit 14 illustrated in Fig 2 also comprises third sensing means 22 and third stimulation means 24. These means 22, 24 are adapted to be connected to the third lead 60 in order to sense and stimulate the right atrium RA. The control circuit 14 also includes fourth sensing means 23 and fourth stimulation means 25. These means 23, 25 are adapted to be connected to the fourth lead 50 in order to sense and stimulate the left atrium LA.

Since a control circuit 14 for controlling a pacer is well known to a person skilled in the art, no further details need to be described here. Fig 2 only functionally shows some of the parts of the control circuit 14 and the control circuit 14 does not necessarily have to be designed in the manner indicated in Fig 2. The control circuit 14 may of course include several other parts. For example the control circuit 14 can be arranged to control the heart stimulating device 10 by sensing the activity of the living being into which the device 10 is implanted. Furthermore, the control circuit 14 can be arranged such that it can communicate via so-called telemetry with an external device. The control circuit 14 may also for example include means for delivering defibrillation signals. It may also be noted that the control circuit 14 may include several different memories, such as a RAM and a ROM. The memory 15 shown may thus be any suitable memory included in the control circuit 14. The memory 15 can thus be for example a RAM, where the signals are only stored for a very short time in order to control the operation of the device 10.

The control circuit 14 is arranged to be able to detect or determine a time cycle corresponding to a normal heart cycle. This can be

done by detecting events in the heart corresponding to a heart cycle. It is also possible to determine a heart cycle by simply setting a time (for example about 1s) that corresponds to a normal heart cycle. The time can for example be set in response to a paced or sensed event and can thereby constitute an escape interval.

Fig 3 shows schematically signals that may be detected by the first 16 and second 17 sensing means during a time cycle. The lower line in Fig 3 refers to signals sensed by the first sensing means 16, i. e. primarily intended for sensing signals in the first ventricle 1V. The upper line in Fig 3 shows signals detected by the second sensing means 17 during a time cycle, i. e. signals that are intended to originate from the second ventricle 2V. It should be noted that the first ventricle 1V can be either the left ventricle LV or the right ventricle RV. The second ventricle 2V is of course the other ventricle.

The control circuit 14 is arranged to detect R-waves (i. e. a QRS complex) in the different ventricles. The control circuit 14 can be arranged to detect such R-waves in a certain window, but preferably the control circuit 14 is arranged to continuously monitor the respective ventricle 1V, 2V for the detection of R-waves, except for during short blanking periods. Normally, the control circuit 14 is also arranged to have a ventricular refractory period after the sensing of an R-wave (or after the delivery of a stimulation pulse). The purpose of detecting the R-waves is primarily in order to be able to control the operation of the device 10. For example, the detection of an R-wave may mean that a stimulation pulse is inhibited, i. e. that no stimulation pulse is delivered since an R-wave has been detected.

It may be remarked that it is also possible to detect whether a delivered stimulating pulse actually results in a depolarisation of the ventricle in question. Such a detection is called capture detection. The present invention is however not concerned with such capture detection. Instead, the invention relates to the problem of determining whether a detected signal in a ventricle that is not stimu-

lated, at least not during the time cycle in question, is actually a detected R-wave from this ventricle, and not for example a far field signal from the other ventricle.

Fig 3 shows that the second sensing means 17 detects a signal S2a essentially simultaneously with a signal S1a detected by the first sensing means 16. In the example discussed it is assumed that no stimulation signal is delivered by the second stimulation means 19, at least not during the time cycle in question when S2a is detected. According to the invention, the control circuit 14 is arranged to determine whether a second signal S2b is detected by the second sensing means 17 during a predetermined time interval T2. The time interval T2 follows after the signal S2a but within the same time cycle as the signal S2a. The time interval T2 starts 20-200 ms after the signal S2a. The time interval T2 is preferably 40-250 ms long. If the signal S2a in fact represents a real R-wave in the second ventricle 2V, then no signal S2b would occur during the time interval T2, since the second ventricle 2V would be refractory during this time if S2a were a real R-wave. However, in case the signal S2a does not represent a real R-wave in the second ventricle 2V, but S1a represents a real R-wave in the first ventricle 1V, then the R-wave in the first ventricle 1V will with a time delay reach the second ventricle 2V and will thereby be detected as the signal S2b. In other words, the signal S2b is an indication of the fact that the signal S2a is in fact not a signal that indicates an R-wave in the second ventricle 2V. It can therefore be assumed that the signal S2a was a far field detection of the signal S1a. An indication of the fact that said signal S2a, which constitutes a suspected far field signal, has been detected is stored in said memory (15).

It should be noted that the time delay it takes from the signal S1a to be detected as S2b in the second ventricle 2V depends on the particular case. This depends inter alia on the position of the electrode members 31, 32; 41, 42 in the heart. The delay can in some cases be as short as 20 ms but in other cases the delay can be for example 150 ms. Consequently, the start of the time interval T2 may depend on the particular case. One preferred starting point of the in-

terval T2 is 50-150 ms, for example 60 ms, after the occurrence of the signal S2a. Also a suitable length of the time interval T2 may depend on the particular case. The time interval T2 may for example be 50-150 ms long or 50-100 ms, for example 80 ms long.

The control circuit 14 is preferably arranged to set the time limit for when the detection S1a and S2a are considered as being essentially simultaneous. For example these signals can be considered to be simultaneous if the time interval between them is less than 25 ms. This requirement is in Fig 3 indicated by the time window TO. TO thus starts when S1a is detected and has a length of for example 25 ms.

The control circuit 14 is arranged to perform the above described algorithm during a plurality of time cycles. The control circuit 14 can be arranged to adjust the setting of at least one control variable of the device 10 if said signal S2a, which constitutes a suspected far field signal, is detected during at least a predetermined number of time cycles. The predetermined number of time cycles can be for example 1, 5 or 10 or any other suitable number. By detecting this type of signal S2a several times, it is more likely that the signal is in fact a far field signal. The control variable that is adjusted may for example be the sensing threshold of the second sensing means 17. This sensing threshold may for example be increased if a number of such far field signals S2a have been detected. By increasing the sensing threshold, the likelihood of detecting a far field signal is reduced. The sensing threshold should of course not be increased so much that the real R-wave in the second ventricle 2V is not detected. However, normally the far field signal is essentially weaker than the real R-wave. However, if in a certain case the far field signal is as strong as the real R-wave from the second ventricle 2V, then the device can be automatically set to operate only in response to signals sensed in the first ventricle 1V.

According to a further embodiment of the invention, the control circuit 14 is arranged to also monitor whether a signal S1b is detected by the first sensing means 16. The control circuit 14 is arranged to

sense the second signal S1b during a time interval T1 that follows after the signal S1a and within the same time cycle as the signal S1a. The time interval T1 starts 20-200 ms after the signal S1a. Exactly when to start the time interval T1 may depend on the particular case. The time interval T1 may thus be set to start for example 50-150 ms after the signal S1a. The length of the time interval T1 may be for example 40-250 ms, preferably 50-150 ms or most preferred 50-100 ms. The control circuit 14 may be arranged such that the predetermined time interval T1 at least substantially coincides with the predetermined time interval T2. The sensing during the time interval T1 and also during the time interval T2 is preferably done during a time cycle when no stimulation signal is delivered by the first stimulation means 18 and no stimulation signal is delivered by the second stimulation means 19.

As explained above, the detection of the signal S2b normally means that the signal S2a was not a real R-wave. Analogously, the detection of the signal S1b ought normally to mean that the signal S1a was no real R-wave. However, in case neither S1a nor S2a is an indication of an R-wave this means that neither the first ventricle 1V nor the second ventricle 2V actually depolarised. If neither ventricle depolarised, then there can not be any transferred signals S2b and S1b. The occurrence of both the signals S1b and S2b is therefore an indication of the fact that the signals S1a and S2a probably have some other cause. For example, these signals may be caused by an external interference.

The control circuit 14 is normally arranged to set different time intervals, or to inhibit or deliver stimulation pulses, in response to detected signals S1a and S2a. However, the detection of both said signal S1b and said signal S2b during a time cycle is, as explained above, an indication of an external interference. Therefore, the control circuit 14 according to the present invention is preferably arranged to modify a set timer period in case said signals S1b and S2b are detected during a time cycle. For example, the signals S1a and/or S2a may involve the resetting of a timer period, for example a ventricular refractory period. The control circuit 14 can therefore

be arranged to annul the set timer period in case said signals S1b and S2b are detected during a time cycle. According to the invention, an indication of the fact that both said signal S1b and said signal S2b have been detected during a time cycle is stored in the memory 15. The memory 15 may for example in this case only constitute a RAM memory wherein this indication is stored for a short time in order to control the device in an appropriate manner, such as to annul the resetting of the mentioned timer period. However, it is also possible that an indication is stored in the memory 15 such that this indication can be transferred to an external device, for example in connection with a medical check-up.

Fig 4 shows a simplified flow chart of the operation of the device 10. The algorithm is performed by the control circuit 14. It is determined whether a signal S1a and a signal S2a occur essentially simultaneously. If this is not the case, then the algorithm for detecting a suspected far field signal ends.

However, if the signals S1a and S2a occur essentially simultaneously, then it is determined whether a signal S2b occurs within the time interval T2. If this is the case, then it is determined whether a signal S1b occurs within T1. If both a signal S2b and a signal S1b have been detected, then this is an indication of the fact that S1a and S2a are probably caused by noise, such as an external interference. The control circuit 14 can then be arranged to take appropriate measures as has been described above. If on the other hand a signal S2b is detected but no signal S1b, then S2a is probably a far field signal and an appropriate measure according to the above description can be carried out.

If no S2b is detected within T2, then it is determined whether a signal S1b is detected within T1. If this is the case, then the signal S1a is probably a far field signal and an appropriate measure is carried out as has been described above. If the signals S1a and S2a occur essentially simultaneously, but neither S2b occurs within T2 nor S1b occurs within T1, then S1a and S2a are probably true events

(true R-waves), and the operation of the device continues as normal.

It should be noted, that although not shown in Fig 4, the control circuit 14 can be arranged such that the different measures are carried out only if the different situations occur a predetermined number of times.

The control circuit 14 is preferably also arranged to maintain the information concerning detected far field signals in the memory 15 such that this information is available to a physician at a medical check-up.

In the flow chart of Fig 4 a yes is indicated by Y and a no by N. It may be noted, that the flow chart is a simplified algorithm. The control circuit 14 is, for example, as mentioned above, arranged to check whether for example S2b is within the time interval T2 only during heart cycles where no stimulation pulse has been delivered by the second stimulation means 19.

The invention also concerns a use of the above described system. According to this use the system is implanted in a human or animal being and the first sensing member 31, 32 is positioned in or at a first ventricle 1V of the heart. The second sensing member 41, 42 is positioned in or at the second ventricle 2V of the heart. The system is used, as explained above, in order to detect whether a signal S2a is in fact not a sensed R-wave but a suspected far field signal from the other ventricle.

The system is preferably used on a human or animal being suffering from congestive heart failure, for example caused by a left or right bundle branch block.

The invention is not limited to the described embodiments but may be varied and modified within the scope of the following claims.

Claims

1. An implantable heart stimulating device (10) comprising:

a control circuit (14) comprising a memory (15), first sensing means (16), adapted to be connected to a first sensing member (31, 32) suited to be positioned so as to transfer signals to said first sensing means (16) for sensing cardiac events related to a first ventricle (1V) of the heart, and second sensing means (17), adapted to be connected to a second sensing member (41, 42) suited to be positioned so as to transfer signals to said second sensing means (17) for sensing cardiac events related to a second ventricle (2V) of the heart,

said control circuit (14) also comprising first stimulation (18) means adapted to be connected to a first stimulation member (31, 32) for delivering stimulation signals to the first ventricle (1V) of the heart, and second stimulation means (19) adapted to be connected to a second stimulation member (41, 42) for delivering stimulation signals to the second ventricle (2V) of the heart,

said control circuit (14) also being arranged to be able to detect or determine a time cycle corresponding to a normal heart cycle, the control circuit (14) also being arranged to perform the following algorithm:

a) determine whether, during a time cycle in which no stimulation signal is delivered by said second stimulation means (19), a signal S2a, sensed by said second sensing means (17), occurs essentially simultaneously with a signal S1a sensed by said first sensing means (16),

b) determine whether a further signal S2b is sensed by said second sensing means (17) within a predetermined time interval T2 which follows after said signal S2a but within the same time cycle as said signal S2a, wherein said predetermined time interval T2 starts 20-200 ms after said signal S2a,

c) if both a) and b) are the case, store in said memory (15) an indication of the fact that said signal S2a, which constitutes a suspected far field signal, has been detected.

2. An implantable heart stimulating device (10) according to claim 1, wherein the control circuit (14) is arranged such that said predetermined time interval T2 is 40-250ms long.

3. An implantable heart stimulating device (10) according to claim 2, wherein said predetermined time interval T2 is 50-150ms long.

4. An implantable heart stimulating device (10) according to any of the preceding claims, wherein the control circuit (14) is arranged such that said predetermined time interval T2 starts 50-150 ms after said signal S2a.

5. An implantable heart stimulating device (10) according to any of the preceding clams, wherein said control circuit (14) is arranged to perform said algorithm during a plurality of time cycles and to adjust the setting of at least one control variable of the device if a signal S2a, which constitutes a suspected far field signal, has been detected during at least a predetermined number of time cycles.

6. An implantable heart stimulating device (10) according to claim 5, wherein said control variable relates to the sensing threshold of said second sensing means (17), and wherein said adjustment involves an increase of said sensing threshold.

7. An implantable heart stimulating device (10) according to any of the preceding claims, wherein said control circuit is arranged to also:

determine whether, during a time cycle in which no stimulation signal is delivered by said first stimulation means (18) and no stimulation signal is delivered by said second stimulation means (19), in addition to said signal S2b also a signal S1b is detected, wherein the signal S1b fulfils the following criteria:

the signal S1b is sensed by said first sensing means (16) within a predetermined time interval T1 which follows after said signal S1a but within the same time cycle as said signal S1a, wherein

this predetermined time interval T1 starts 20-200 ms after said signal S1a, wherein the control circuit (14) is arranged to store in said memory (15) an indication that both said signal S1b and said signal S2b have been detected during a time cycle.

8. An implantable heart stimulating device (10) according to claim 7, wherein said control circuit (14) is arranged such that said predetermined time interval T1 at least substantially coincides with said predetermined time interval T2.

9. An implantable heart stimulating device (10) according to claim 7 or 8, wherein said control circuit (14) is arranged to set at least one timer period in response to detected signals S1a and/or S2a, and wherein, when both said signal S1b and said signal S2b have been detected during a time cycle, the control circuit (14) is arranged to modify said set timer period.

10. An implantable heart stimulating device (10) according to claim 9, wherein said set timer period in response to detected signals S1a and/or S2a involves the resetting of a timer period and wherein said modification means that the resetting of the timer period is annulled.

11. An implantable heart stimulating system comprising:

an implantable heart stimulating device (10) according to any of the preceding claims, and

a first (30) and a second (40) lead connected to said device (10), wherein said first sensing member (31, 32) is arranged on said first lead (30) and said second sensing member (41, 42) is arranged on said second lead (40).

12. An implantable heart stimulating system according to claim 11, wherein said first stimulation member (31, 32) is arranged on said first lead (30) and said second stimulation member (41, 42) is arranged on said second lead (40).

13. An implantable heart stimulating system according to claim 12, wherein said first stimulation member (31, 32) is the same member as said first sensing member (31, 32) and said second stimulation member (41, 42) is the same member as said second sensing member (41, 42).

14. Use of the system according to any of the claims 11-13, wherein said system is implanted in a human or animal being and wherein said first sensing member (31, 32) is positioned in or at a first of the ventricles (1V) of the heart of said human or animal being and wherein said second sensing member (41, 42) is positioned in or at the second ventricle (2V) of said heart.

15. Use according to claim 14, wherein the control circuit (14) is arranged to sense said signals S1a and S2a during a portion of the heart cycle where possible R-waves are expected to be sensed in the ventricles (1V, 2V), and wherein said algorithm is used to detect whether the signal S2a is in fact not a sensed R-wave from the second ventricle (2V) but a suspected far field signal from the first ventricle (1V).

16. Use according to claim 15, wherein information about detection of one or more such suspected far field signals are stored in said memory (15) such that this information is accessible to a physician at a medical check-up.

17. Use according to any of the claims 14-16, wherein the system is used on a human or animal being suffering from congestive heart failure.

18. Use according to any of the claims 14-17, wherein the system is used on a human or animal being suffering from a left or right bundle branch block.

Abstract

The invention concerns an implantable bi-ventricular heart stimulating device (10) comprising a control circuit (14) with first sensing (16) and first stimulation means (18), and second sensing (17) and second stimulation means (19). The control circuit (14) is arranged to perform a certain algorithm and to determine whether a signal S2a, sensed by said second sensing means (17), occurs essentially simultaneously with a signal S1a sensed by said first sensing means (16). Furthermore, the control circuit (14) determines whether a further signal S2b is sensed by said second sensing means (17) within a predetermined time interval T2 which follows after said signal S2a but within the same time cycle as said signal S2a. With the invention a possible far field sensing can be detected. The invention also concerns a system including such a device (10) as well as a use of this system.

(Fig 1)

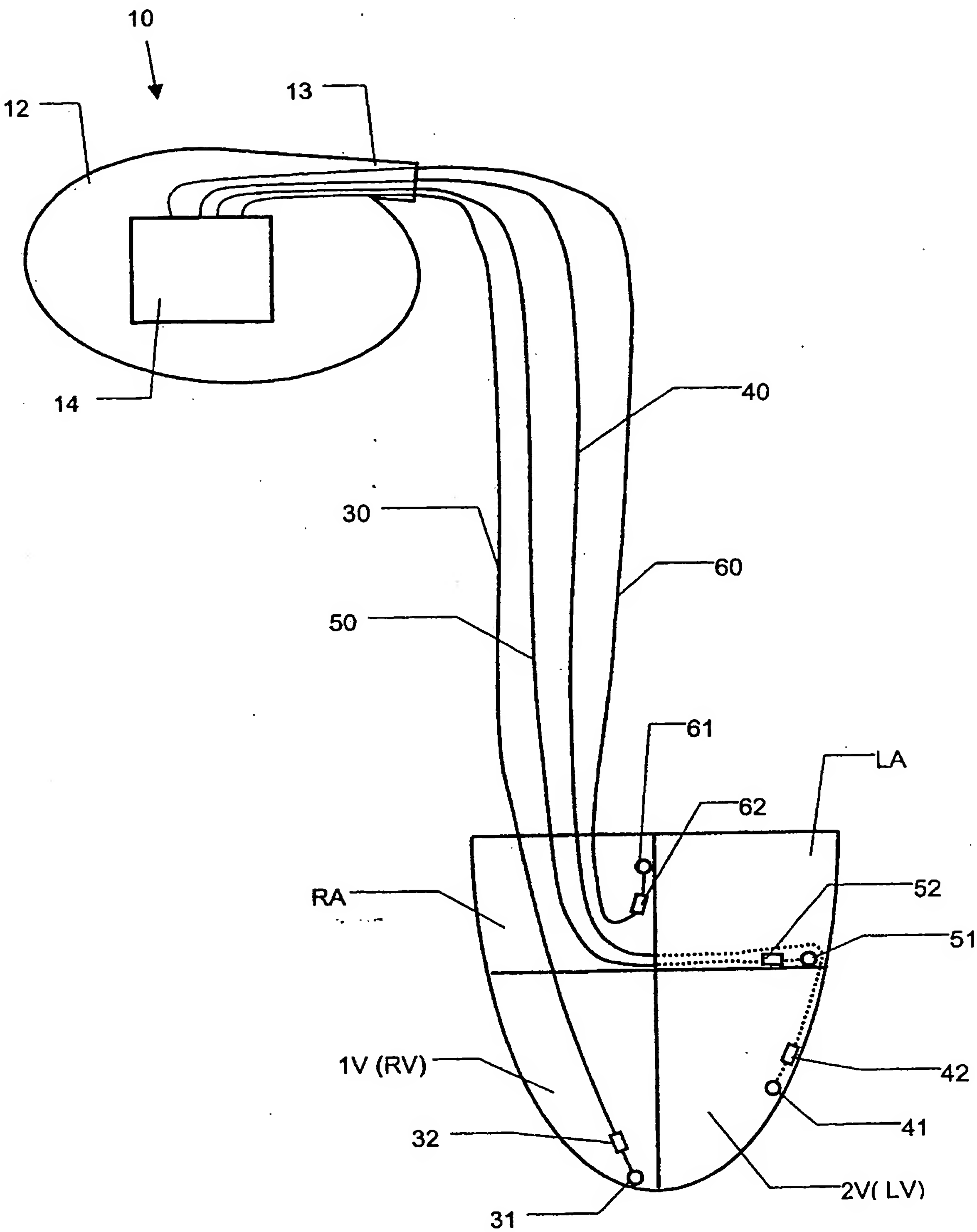

FIG 1

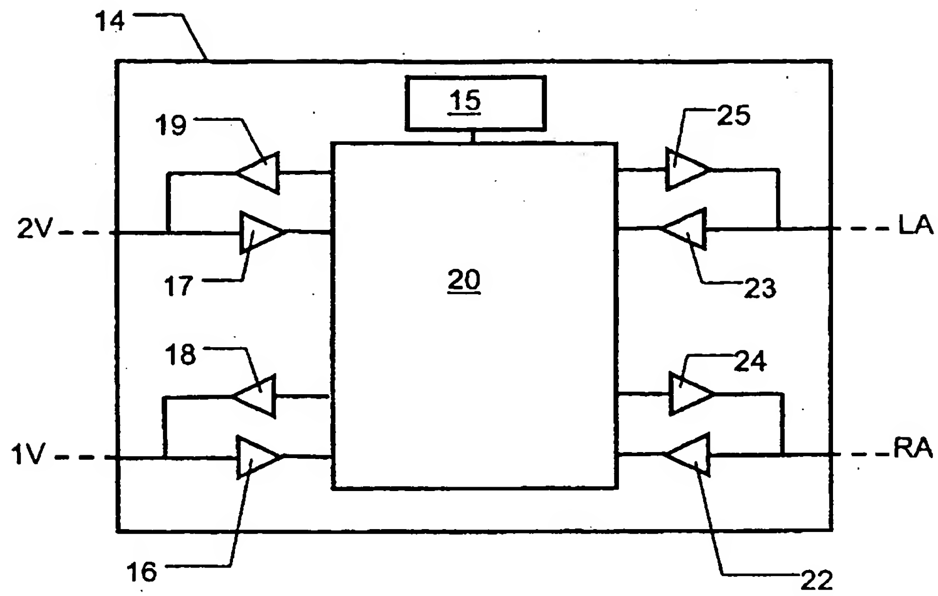
14
15
19
25
2V
LA
20
17
23
18
24
1V
RA
16
22

FIG 2

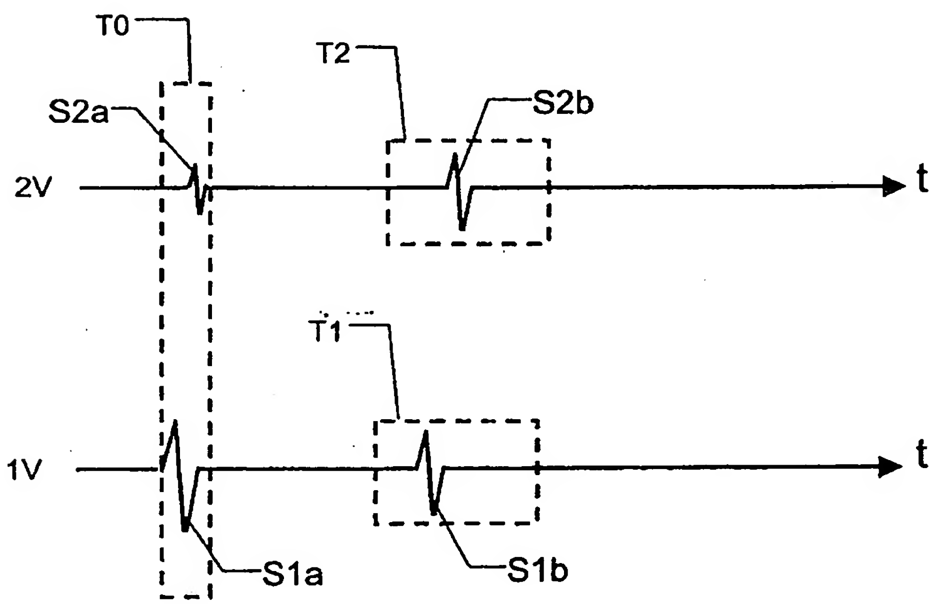
T0
T2
S2a
S2b
2V
t
T1
1V
t
S1a
S1b

FIG 3

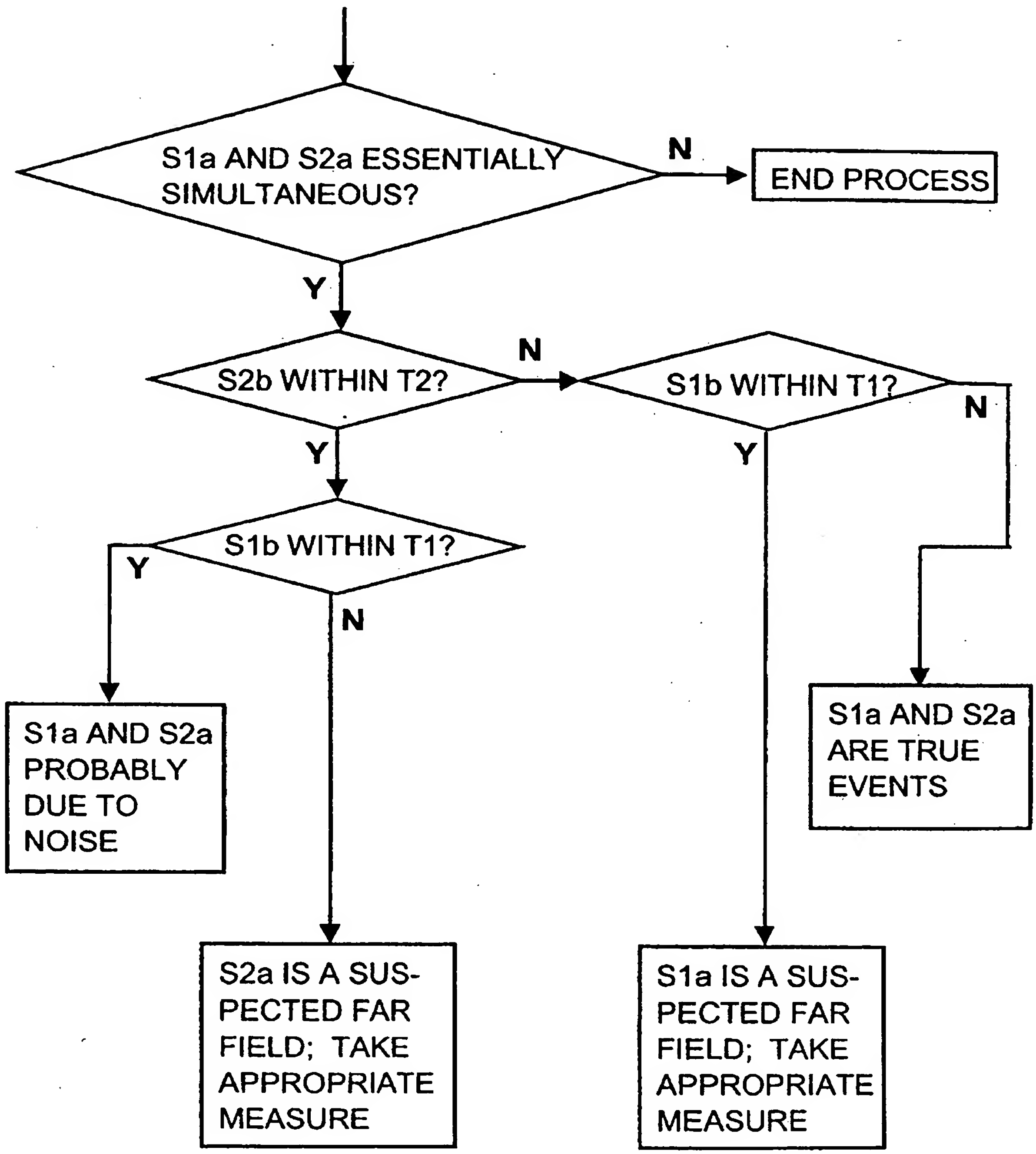
S1a AND S2a ESSENTIALLY SIMULTANEOUS?
N
END PROCESS
Y
S2b WITHIN T2?
N
S1b WITHIN T1?
N
Y
Y
S1b WITHIN T1?
Y
N
S1a AND S2a PROBABLY DUE TO NOISE
S1a AND S2a ARE TRUE EVENTS
S2a IS A SUS-PECTED FAR FIELD; TAKE APPROPRIATE MEASURE
S1a IS A SUS-PECTED FAR FIELD; TAKE APPROPRIATE MEASURE

FIG 4